

THE ACULEATE HYMENOPTERA OF SHOTOVER HILL, OXFORDSHIRE

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ABSTRACT

Five years of new survey work on Shotover Hill (2000–2004) for aculeate Hymenoptera are presented and compared with newly collated historic records. This study has recorded 184 species, which when combined with the results of surveys in the 1980s, places the total of recently recorded aculeate species at 209. By comparison, in the years before 1939 an estimated total of 203 species had been accumulated. Sixty-two of the species that were recorded before 1939 have not been observed in recent years, yet the recent work (1980s–2004) has added 68 species (54 by this study). The nesting requirements of these ‘formerly recorded’ and ‘recently added’ species differ, and are shown to be consistent with the land use changes since the 1930s. Site quality scoring indices suggest that when compared with other UK sites, Shotover Hill remains an important site for wasps and bees. The all-time total of aculeate Hymenoptera for Shotover Hill is calculated to be 271 species.

INTRODUCTION

Like the many small areas of sandy soil in Oxfordshire, Shotover Hill developed as heath through being suitable only for rough grazing and pasture. In the 20th century, Shotover was spared the agricultural ‘improvement’ of many local heaths through its proximity to Oxford, gaining a measure of protection as an area of public enjoyment and academic study.

Much of the current interest in aculeate Hymenoptera on Shotover Hill stems from work in the early years of the 20th century by staff of Oxford University Museum of Natural History. By 1939, 141 species had been recorded for Shotover (Salzman, 1939), rising to 185 species by 1987 (Steel, 1984; M. E. Archer, pers. comm.). Subsequent work on the source material by the authors has shown that when common and widespread species are included from Salzman (1939), the overall total of Aculeata for Shotover Hill by the 1980s (before the addition of records presented in this study) is estimated to be 217 species.

A site with > 150 species of aculeate can be considered ‘Class 1’ in Britain (Steele, 1984), especially for locations that are some distance from East Anglia and the south coast of Britain (M. E. Archer, pers. comm.). Clearly, Shotover Hill would rank as an important site on the basis of accumulated species, however 99 of these species were not re-recorded by the subsequent work of the 1980s (Steel, 1984; M. E. Archer pers. comm.). Since the 1930s, scrub encroachment on Shotover has considerably reduced the extent of open grassland, heath and bare soil, and without further survey work, an historic total of 185 species may not be a true reflection of the current status of the Aculeata on Shotover Hill.

SITE DESCRIPTION

Shotover Hill (summit: 171 m amsl at SP564063) is 3 km east of Oxford, and is a small sandstone plateau, 100m above the Thames Clay Vales and within the Midvale

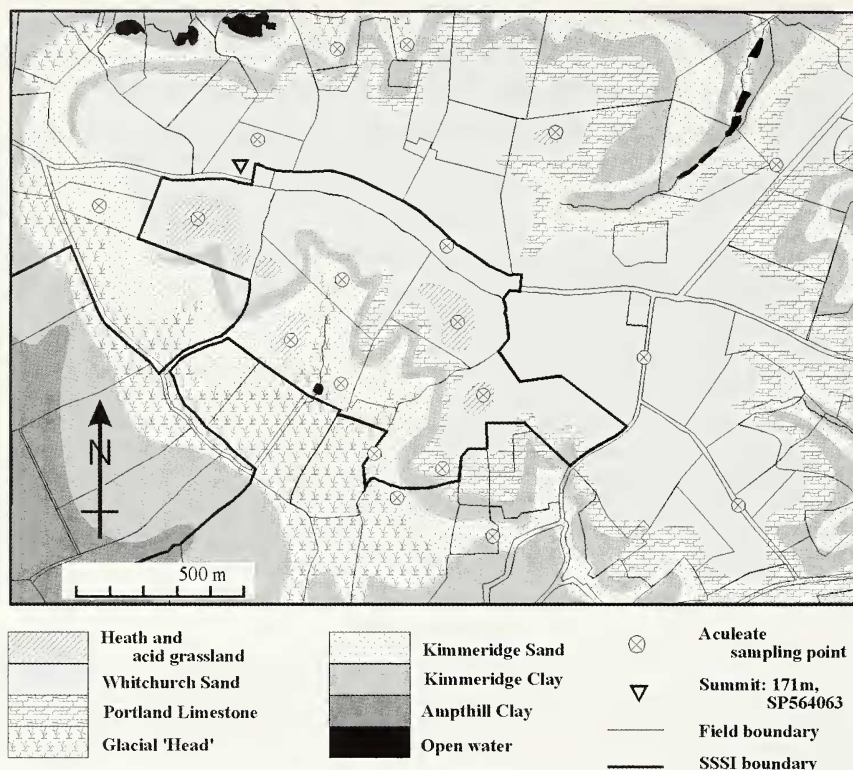


Figure 1. A plan of Shotover Hill showing the principal aculeate sampling points, geology and areas of heath and acid grassland.

Ridge Natural Area (English Nature, 1997). Below the Cretaceous capping of Whitchurch Sand (Fig. 1) are strata of Portland Limestone and Kimmeridge Clay (Jurassic) which, at Shotover, includes associated beds of sand and coarse stone with a range of different textures. In places, the lower slopes are covered with shallow deposits of glacial clay or 'head'. The land use is mixed and comprises heathland scrub, secondary woodland of various ages, pasture, large gardens and a little arable agriculture. The area represented by surveying in this study is about 250 hectares.

Much of the south west side of Shotover Hill is taken up with a public access Country Park, most of which is designated an SSSI (Fig. 1) for its flora and invertebrate fauna. Over recent years, the heathland on Shotover has been enlarged and although the area of *Calluna* heather is small (about 1.5 hectares), it is a relatively large expanse for the County of Oxfordshire.

On the basis of archive photographs spanning the 20th century (including many aerial photographs) and anecdotal evidence from local residents, it has been possible to interpret the changing habitats over this period. Until the middle years of the 20th century, Shotover was predominantly rough grazing and low-grade pasture with some areas of crop cultivation and isolated woodland. Then, between c.1940 and c.1960, the area was considerably altered through various significant influences: the

reduction of pasture-based farming, reduced rabbit grazing following the onset of myxomatosis, and a period of substantial disturbance by public and military vehicles. Therefore, until about 1950 extensive areas of short vegetation and bare soil would have been present, and would have been of considerable benefit to ground nesting invertebrates. Since 1950, scrub vegetation has grown up and matured in places, creating extensive pioneer woodland with only isolated areas of mown or rabbit-grazed grassland.

ASSESSMENT OF HISTORIC RECORDS

Appendix 12 of Steel (1984) provides a list of aculeate Hymenoptera recorded on Shotover Hill to that date: that is, Salzman (1939) plus the later work of O'Toole. However in returning to the original data, possible errors in the extraction of data from Salzman (1939) were highlighted, and this accounts for small differences between the species given here and those in Steel (1984). For this study, six species are discounted from Steel's list: *Ancistrocerus antilope* (Panzer), *Passaloecus gracilis* (Curtis), *Andrena bucephala* (Stephens), *A. nigroaenea* (Kirby), *Bombus ruderatus* (F.) and *B. rupestris* (F.), and 11 species are added: *Arachnospila anceps* (Wesmael), *Ancistrocerus oviventris* (Wesmael), *A. trifasciatus* (Müller), *Crabro peltarius* (Schreber), *Mimesa equestris* (F.), *Passaloecus monilicornis* Dahlbom, *Andrena pilipes* (F.), *A. trimmerana* (Kirby), *Anthidium manicatum* (L.), *Nomada flavoguttata* (Kirby) and *Bombus sylvestris* (Lepeletier). This adjustment increases Steel's accumulated total for that time (1984) from 174 to 179 species.

Incorporating the above adjustment, Salzman (1939) lists 141 species of aculeate as being specifically associated with 'Shotover', and a further 62 species are listed as widespread or 'common round Oxford'. Many of these common species would have been present on Shotover Hill, and probably recorded there, but were not specifically listed as such. The number of species actually recorded on Shotover in the early 20th century must, therefore, be between the minimum of 141 and a maximum of 203 (Table 1), and introduces some uncertainty into the interpretation of any subsequent changes in the aculeate fauna.

Table 1. Summary of previous aculeate Hymenoptera recording on Shotover Hill.

Historic records	Number of species based on '1939 minimum'	Species 'common round Oxford' (1930s)	Number of species based on '1939 maximum'
Species recorded before 1939 (Salzman, 1939)	141	+ 62	203
of which			
Species remaining unrecorded by the 1980s	99	+ 32	131
Species refound in the 1980s by O'Toole and Archer	42	+ 30	72
Species added in the 1980s by O'Toole and Archer	44	–	14
Total species recorded by the 1980s	185	+ 32	217

'1939 minimum' includes species specifically recorded for 'Shotover' in Salzman (1939)
'1939 maximum' includes all species listed as either for 'Shotover' or 'common round Oxford'.

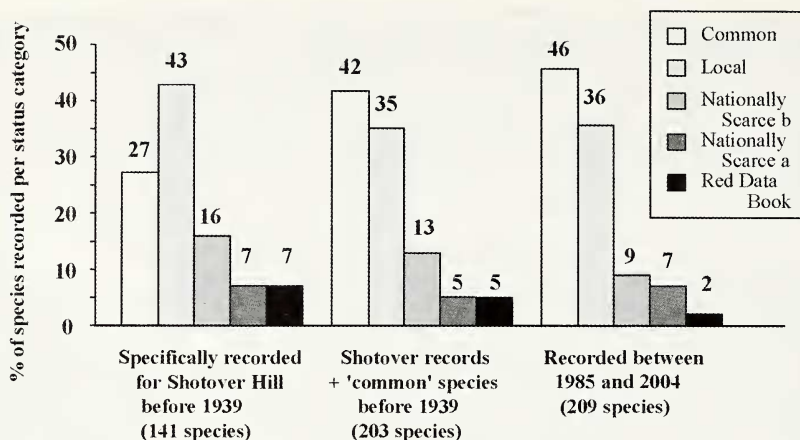


Figure 2. Status profiles of aculeate Hymenoptera records showing the effect of including implicit 'common' species from earlier records. National statuses after Falk (1991) and Ball (1997).

In the early 1980s, Mr Chris O'Toole (Department of Entomology, Oxford University) made two visits to survey Aculeata on Shotover Hill, and Dr Michael Archer (BWARS) made survey visits in 1985 and 1987. These visits recorded a total of 86 species, of which 42 had been previously noted for Shotover Hill by Salzman (1939), and 44 were formally new records for Shotover (Table 1). However, when considering those species that Salzman notes as 'common round Oxford', these statistics are altered to 72 species re-recorded and 14 added. Consequently, the all-time total of Aculeata on Shotover Hill by 1987 was formally raised to 185, or when 'common' species are added, to an estimated total of 217 (Table 1).

Table 1 shows that the exclusion of common aculeate species would greatly affect a comparison between current and previous work. Therefore it is necessary to investigate some feature of the recorded species to justify either exclusion of the implicit 'common' species (i.e. '1939 minimum' in Table 1) or their inclusion (i.e. '1939 maximum'). It is proposed here that the national statuses for Aculeata (Falk, 1991; Ball, 1997) would be a suitable indicator, even though the conservation status of some species will have changed since the 1930s.

Figure 2 shows that there is a very marked similarity between the status profiles of early and recent work, but only when the 'common' species are included. Although some of the 'common' species may not have been recorded on Shotover in the 1930s, the inclusion of all 'common' species from Salzman (1939) would clearly provide the most relevant comparisons with recent work. It is unlikely that changes in status over time would greatly affect this conclusion, and all 'common' species (1939 maximum) are assumed to have been on Shotover in the 1930s for the purposes of analysis herein.

SURVEY METHODOLOGY (2000–2004)

Specimens were collected over the five years from 2000 to 2004, and sampled by water trap, Malaise trap and by hand net. Pitfall traps yielded most of the ants and a few other Hymenoptera.

Most of the trapping activity was concentrated at the points shown in Fig. 1. Although the distribution of sampling is reasonably representative of the area, it was not possible to give the same amount of attention to all locations, and not all locations were sampled using the same methods. Some of the sampling was within the public park where passive traps cannot be left unattended for more than a day or two without risk of disturbance. However, some of the areas of heavy public usage coincide with the heathland habitat where many of the scarcer Aculeata would be expected. In these areas there is, therefore, a bias towards netting by hand. In light of these limitations, no attempt has been made to analyse the species profiles from the areas of different soil or habitat within the site.

RESULTS

In this study 184 species of aculeate Hymenoptera were recorded during the period 2000–2004 (Appendix 1), of which 54 are new records for Shotover Hill. Table 2 gives a summary of these species by family/sub-family (BWARS, 2005), and Table 3 shows a summary of their national statuses (Falk, 1991; Ball, 1997), together with more recent ratings derived from national records for the period 1970 to 2004 (Archer, 2004a, 2004b, 2005; BWARS, 2003). The status of five species were ‘unknown’ to Ball (1997) but have been classified since by Archer (2004a & b) as either ‘universal’ or ‘widespread’. For completeness these five species have been given retrospective equivalent statuses, however, this does not affect the analysis that follows.

When the records from this study are supplemented by the work of C. O’Toole and M. E. Archer in the 1980s, a further 25 species can be included in the analysis as representative of recent recording (Appendix 2). From the early 1980s until 2004, 209 species have been recorded, of which 116 are formally new records for Shotover Hill. However, 48 of these 116 species are amongst those that Salzman (1939) considered ‘common round Oxford’, leaving 68 species as entirely new records for Shotover.

Table 2. Tabulation by family/subfamily of species recorded in this study (2000–2004).

	Family	No. of species
Ants	Formicidae	8
Wasps	Chrysididae	6
	Tiphiidae	2
	Mutillidae	1
	Pompilidae	13
	Eumeninae	4
	Vespinae	4
	Crabonidae	47
Bees	Colletinae	8
	Andreninae	24
	Halictinae	28
	Megachilinae	11
	Anthophorinae	17
	Apinae	11
All species	Total	184

Table 3. Tabulation by national status of species recorded in this study (2000–2004).

Status Falk (1991) Ball (1997)		Status Archer (2004a&b, 2005) BWARS (2003)	
	No.		No.
Common	89	Universal	92
Local	65	Widespread	57
Nationally Scarce b	14	Restricted	11
Nationally Scarce a	13	Scarce	17
Red Data Book 3	2	Rare	6
Red Data Book 2	1	Very Rare	1
Red Data Book 1	0		
Totals	184		184

Table 4. Quality scoring indices for the recent surveys (1980s–2004) and pre-1939 on Shotover Hill, together with quality indices for other UK sites of comparative area.

Site	Area (ha)	No. of Species	Quality Score	Aerial Nester Frequency		Parasitic Load	
				Wasps	Bees	Wasps	Bees
Chafford Hundred, Essex ¹	137	218	5.96	20.3	22.3	19.5	26.4
Ambersham Common, West Sussex ²	212	219	4.53	38.5	23.3	16.1	22.3
Iping Common, West Sussex ²	172	219	4.51	42.4	21.0	12.4	23.5
Sherwood Forest, Nottingham- shire ³	390	100	2.96	47.6	19.4	17.6	25.0
Shotover 1980s–2004⁴	250	209	2.89	51.3	27.4	23.1	32.3
Shotover pre-1939⁴	~ 250	203	–	44.6	23.4	29.6	29.6
Crow Wood, Yorkshire ³	152	105	2.53	20.4	9.4	16.9	28.9
Blaxton Common, Yorkshire ³	150	109	1.85	43.1	13.9	15.0	26.5
Risby Warren, Lincolnshire ³	170	63	1.81	12.5	8.3	17.2	29.4
Skipworth Common, Yorkshire ³	312	69	1.57	42.4	30.0	13.2	35.5

¹O'Toole (1998)²Archer & Edwards (2002)³Archer & Burn (1995)⁴This study

Of the species listed for the early 20th century by Salzman (1939) 62 remain unrecorded by the recent surveys (Appendix 3). Including all surveys, the total number of species so far recorded on Shotover Hill will be close to the estimated maximum total of 271: about half of the national fauna of Aculeata.

Quality scoring indices

Following work by Archer & Burn (1995) to derive indices that describe the aculeate fauna of a site, quality scores have been calculated for Shotover Hill in a similar manner. These are the Quality Score, Aerial Nester Frequency and Parasitic Load, and permit objective comparisons with other UK sites for which similar work

has been presented. The Quality Score used here is the total score after assigning each recorded species with a value relating to its national status (but not its abundance): e.g., common = 1, very rare = 32, (Archer & Burn, 1995), divided by the total number of species in the survey. Thus the calculated index includes a measure of the proportion of scarcer species at each site. For the most recent survey work on Shotover Hill (2000–2004) the Quality Score is 2.72, which increases to 2.89 when combined with the work in the 1980s by O'Toole and Archer.

Aerial Nester Frequency expresses the number of Aculeata that nest above ground as a proportion of the total soil and aerial nest builders, and Parasitic Load expresses the number of parasitoids and cleptoparasites as a proportion of the total host and parasite species. These indices are calculated for bees and wasps separately. Table 4 shows published indices for eight UK sites that are notable for their aculeate Hymenoptera (Archer & Burn, 1995; O'Toole, 1998; Archer & Edwards, 2002). As Quality Scores are partly influenced by the area of a site (Archer & Burn, 1995), only those sites in the range 100–400 ha were chosen, being within 150 ha of the area surveyed in this study. Table 4 lists the chosen sites in order of Quality Score, which places Shotover Hill centrally among the other notable sites.

It would not be relevant to calculate the site Quality Score for the historic data from Shotover Hill, as the statuses would not be accurate for the early 20th century, and comparison could be misleading. However, Aerial Nester Frequency and Parasitic Load can be legitimately derived for both historic and recent data, and these are shown in Table 4.

DISCUSSION

Rare and notable species

Considering the influences of changing habitat, and possibly climate, it is to be expected that the status of mobile species such as Hymenoptera will change over time, and Table 3 should be viewed with this in mind. Of the three 'Red Data Book' (RDB) species, the cleptoparasitic bee *Sphecodes niger* (von Hagens) is now listed as 'very rare' in Britain (Archer, 2005). However, the 'Bee Wolf' wasp, *Philanthus triangulum* (F.) (RDB2 but provisionally RDB4) and cleptoparasitic bee *Nomada lathburiana* (Kirby) (RDB3) have become much less scarce and are now considered widespread (Archer 2004a & b). Table 3 shows that 30 (16%) of the species recorded by this study are either 'Nationally Scarce' or 'RDB', but this is not an especially high proportion compared with other published studies (e.g. O'Toole, 1998; Archer & Edwards, 2002). However, it should be noted that it is easier to observe a species becoming more common by recording its presence, than it is to suspect that a species is becoming scarcer by eventually noting its absence.

Several are new records for this far north in the region: for example the solitary wasp *Astata boops* (Schränk) and its associated cleptoparasite *Hedychridium roseum* (Rossius). Were it not for the paucity of recent recording of Aculeata in the region, these new records could be indicators of northward migration.

Comparison with historic records

Reworking past records from Shotover Hill has shown that in the early 20th century the sandy heath and pasture of the hill supported a remarkable diversity of aculeate Hymenoptera. Notwithstanding the uncertainty of including implicit common species, a total of about 200 species would rank as a very good habitat by current standards. In comparison, this and recent studies (1980s–2004) have

Table 5. National status and nesting requirements of 'Formerly recorded', 'Recently added' and 'Continuously present' species on Shotover Hill.

	'Formerly recorded' Species not recorded since 1939. %	'Recently added' Species newly added 1980s–2004. %	'Continuously present' Species recorded in both early and recent surveys. %
Common	19	36	53
Local	40	41	33
Nationally Scarce b	18	6	10
Nationally Scarce a	8	13	4
RDB	15	4	0
	No. (%)	No. (%)	No. (%)
Soil nesters	30 (48)	26 (38)	65 (46)
Aerial nesters	10 (16)	23 (34)	37 (26)
Total species	62	68	141

recorded 209 species, which includes 68 that were either not present or not recorded on Shotover in the 1930s. Clearly some of these species went unrecorded, such as the common ant *Myrmica ruginodis* Nylander, but 68 species seems to be too many to have gone unnoticed by the experienced collectors of Oxford University in those early years. Considering the 62 species that have not been observed since 1939, the habitat requirements of these 'formerly recorded' and 'recently added' groups of aculeate species warrants investigation.

Table 5 shows the distribution of national statuses within the 'formerly recorded', 'recently added' and 'continuously present' groups of species. Although some species may have been present but not recorded in the various surveys, and current statuses may not be representative of the 1930s, the large number of species involved would suggest that most of the differences are due either to habitat change, or species becoming generally more scarce or common in the region.

As might be expected, there is a high proportion of the more ubiquitous common species (53%) recorded continuously through both surveys. Of the scarce and possibly more habitat specific species, just 14% (all Nationally Scarce and no RDBs) have survived on Shotover from the early 20th century to the present day (Table 5). In contrast to this, 41% and 23% of 'formerly recorded' and 'recently added' species respectively are Nationally Scarce or Red Data Book. (Separate comparison of the 'formerly recorded' and 'recently added' groups also mitigates the earlier decision to include the implicit 'common' species.)

Of particular interest is the proportion of 'formerly recorded' and 'recently added' species that build their nests specifically either in the soil or in aerial cavities (e.g., hollow plants stems and holes in dead wood). In Table 5 it can be seen that there are more soil nesters in the 'formerly recorded' group of species (30) than in the 'recently added' group (26), yet many more aerial nesters have been 'recently added' (23) than are in the 'formerly recorded' group (10). The change over time from soil to aerial nesting is statistically significant at the 5% level (d.f. = 1, $\chi^2 = 4.54$, $p < 0.05$), and is entirely consistent with the habitat changes over the period. In the early 20th century, Shotover had much more pasture and patches of sunlit soil, especially on

the warmer south side of the hill. In contrast to this, much of the obsolete pasture and rabbit-grazed grassland has now succeeded to woody scrub, and bare soil is reduced to paths, areas of conservation effort and public disturbance. When wasps and bees are considered separately, Table 4 shows a very similar increase ($\sim 16\%$) in Aerial Nester Frequency for both groups since the 1930s.

Comparing the pre-1939 and post 1980s surveys, Parasitic Load for bees rose a little over the interceding years from 29.6 to 32.3 (+9%), and for wasps fell from 29.6 to 23.1 (–22%). However, these changes are not statistically significant. When compared with the Parasitic Load values given for the other eight UK sites (Table 4), Shotover appears to have a higher proportion of parasitic species than most of the other listed sites.

CONCLUSION

The 184 species recorded by this study show that, on this basis alone, Shotover Hill retains a good diversity of aculeate Hymenoptera. An area of 250 hectares in the south of England, which includes a range of heath and scrub woodland habitats, would be expected to yield a reasonable diversity of Aculeata. However, Shotover Hill is some distance from the particularly diverse southern coastal sites and is therefore notable in supporting such a diversity of Aculeata in the south midlands of Britain. Furthermore, several of the species recorded in this study are close to the north-western limit of their UK and European ranges.

The recording of aculeate Hymenoptera on Shotover Hill in this study, and over the past 100 years, has shown that the overall species diversity has remained fairly constant at just over 200 species, even though the land use and vegetation have changed. However, as pasture and short heathy scrub have been replaced, in part, by successional woodland, it appears that the profile of aculeate species has changed in a manner that this succession would suggest. When comparing those species that have not been recorded since 1939, for whatever reason, with those that have been recorded more recently, there has been a small but consistent shift from soil to aerial nesting in both wasps and bees. Measures could be taken to increase the range of bare soil habitats, and thereby avoid a possible trend towards fewer soil nesting species. Nevertheless, this study of aculeate Hymenoptera has shown that Shotover Hill remains an important habitat for this specialised group of invertebrates.

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APPENDIX 1

Aculeate Hymenoptera (184 species) recorded on Shotover Hill, 2000–2004. National statuses (BWARS, 2003; Archer, 2004a, 2004b & 2005) as Universal (U), Widespread (W), Restricted (RE), Scarce (S), Rare (R), Very rare (VR) and (new) indicates a new record for Shotover Hill by this study.

Chrysididae: *Hedychridium roseum* (Rossius) (S, new), *H. ardens* (Latreille in Coquebert) (U), *Trichrysis cyanea* (L.) (W), *Chrysis angustula* Schenck (W, new), *C. ignita* (L.) (U), *C. impressa* Schenck (U, new).

Tiphidae: *Tiphia femorata* F. (S, new), *T. minuta* Vander Linden (W).

Mutillidae: *Myrmosora atra* Panzer (W).

Formicidae: *Myrmica lobicornis* Nylander (U, new), *M. rubra* L. (U), *M. ruginodis* Nylander (U, new), *M. scabrinodis* Nylander (U, new), *Formica fusca* L. (U), *Lasius flavus* (F.) (U), *L. brunneus* (Latreille) (RE, new), *L. niger* (L.) (U).

Pompilidae: *Priocnemis perturbator* (Harris) (U), *P. coriacea* Dahlbom (R), *P. parvula* Dahlbom (U), *P. exaltata* (F.) (U, new), *P. fennica* Haupt (W, new), *P. hyalinata* (F.) (S, new), *P. gracilis* Haupt (S), *P. schioedtei* Haupt (U), *Dipogon subintermedius* (Magretti) (U, new), *Caliadurgus fasciellus* (Spinola) (S, new), *Arachnospila anceps* (Wesmael) (U), *Evagetes crassicornis* (Shuckard) (U), *Anoplius nigerrimus* (Scopoli) (U, new).

Vespididae: *Gymnomerus laevipes* (Shuckard) (S), *Symmorphus bifasciatus* (L.) (U), *Ancistrocerus gazella* (Panzer) (W, new), *A. trifasciatus* (Müller) (U), *Dolichovespula sylvestris* (Scopoli) (U), *D. media* (Retzius) (W, new), *Vespula vulgaris* (L.) (U), *V. germanica* (F.) (U).

Crabronidae: *Astata boops* (Schrank) (RE, new), *Tachysphex pompiliiformis* (Panzer) (U), *Trypoxylon attenuatum* Smith, F. (U), *T. clavicerum* Lepeletier &

Serville (W, new), *T. medium* de Beaumont (U, new), *Crabro peltarius* (Schreber) (U), *Crossocerus ovalis* Lepetelier & Brullé (U, new), *C. pusillus* Lepetelier & Brullé (U), *C. cetratus* (Shuckard) (W, new), *C. megacephalus* (Rossius) (U), *C. podagricus* (Vander Linden) (U), *C. quadrimaculatus* (F.) (W), *C. dimidiatus* (F.) (U), *Ectemnius cavifrons* (Thomson) (U), *E. continuus* (F.) (U), *E. lituratus* (Panzer) (RE, new), *E. cephalotes* (Olivier) (W, new), *Rhopalum clavipes* (L.) (U), *Lindenius panzeri* (Vander Linden) (RE, new), *L. albilabris* (F.) (U), *Entomognathus brevis* (Vander Linden) (W), *Oxybelus unigumis* (L.) (U), *Mimesa equestris* (F.) (U), *Mimumesa dahlbomi* (Wesmael) (W, new), *Psenulus pallipes* (Panzer) (W), *P. concolor* (Dahlbom) (W, new), *P. schencki* (Tournier) (R, new), *Pemphredon lugubris* (F.) (U), *P. inornata* Say (U), *P. lethifera* (Shuckard) (U), *P. morio* Vander Linden (S, new), *Passaloeus corniger* Shuckard (W), *P. insignis* (Vander Linden) (W), *P. gracilis* (Curtis) (W, new), *P. singularis* Dahlbom (W, new), *Spilomena curruca* (Dahlbom) (W, new), *Mellinus arvensis* (L.) (U), *Didineis lunicornis* (F.) (S, new), *Nysson spinosus* (Forster) (U), *N. trimaculatus* (Rossius) (W), *N. dimidiatus* Jurine (S), *Gorytes quadrifasciatus* (F.) (W), *Harpactus tumidus* (Panzer) (U), *Argogorytes mystaceus* (L.) (U), *Philanthus triangulum* (F.) (W, new), *Cerceris rybyensis* (L.) (RE), *C. arenaria* (L.) (W).

Colletinae: *Colletes succinctus* (L.) (U, new), *C. similis* Schenck (W, new), *C. davesanus* Smith, F. (U, new), *Hylaeus cornutus* Curtis (S), *H. annularis* (Kirby) (RE, new), *H. communis* Nylander (W), *H. hyalinatus* Smith, F. (W), *H. confusus* Nylander (U, new).

Andreninae: *Andrena haemorrhoa* (F.) (U), *A. flavipes* Panzer (RE), *A. nitida*, (Müller) (W), *A. nigroaenea* (Kirby) (U), *A. bicolor* F. (U), *A. scotica* Perkins (U), *A. fucata* Smith, F. (U), *A. helvola* (L.) (W), *A. fulva* (Müller in Allioni) (U), *A. clarkella* (Kirby) (U), *A. apicata* Smith, F. (S), *A. fuscipes* (Kirby) (U, new), *A. denticulata* (Kirby) (U), *A. barbilabris* (Kirby) (U), *A. humilis* Imhoff (S), *A. chrysosceles* (Kirby) (W), *A. labiata* F. (S), *A. semilaevis* Perez (U), *A. falsifica* Perkins (R, new), *A. minutula* (Kirby) (U), *A. subopaca* Nylander (U), *A. ovatula* (Kirby) (W), *A. wilkella* (Kirby) (U, new), *A. dorsata* (Kirby) (W).

Halictinae: *Halictus rubicundus* (Christ) (U), *H. tumulorum* (L.) (U), *Lasioglossum leucozonium* (Schränk) (W), *L. quadrimotatum* (Kirby) (R), *L. lativentre* (Schenck) (W), *L. calceatum* (Scopoli) (U), *L. albipes* (F.) (U), *L. malachurum* (Kirby) (RE, new), *L. pauxillum* (Schenck) (RE, new), *L. fulvicorne* (Kirby) (W), *L. villosulum* (Kirby) (U), *L. punctatissimum* (Schenck) (W), *L. minutissimum* (Kirby) (W), *L. parvulum* (Schenck) (W), *L. rufitarse* (Zetterstedt) (W, new), *L. smeathmanellum* (Kirby) (U), *L. morio* (F.) (W), *L. leucopus* (Kirby) (U), *Sphecodes gibbus* (L.) (W), *S. reticulatus* Thomson (S, new), *S. monilicornis* (Kirby) (U), *S. pellucidus* Smith, F. (W), *S. ephippius* (L.) (W), *S. niger* von Hagens (VR, new), *S. puncticeps* Thomson (W, new), *S. ferruginatus* von Hagens (S), *S. crassus* Thomson (RE), *S. geoffrellus* (Kirby) (U).

Megachilinae: *Anthidium manicatum* (L.) (W), *Chelostoma florissomne* (L.) (W), *C. campanularum* (Kirby) (RE), *Osmia rufa* (L.) (U), *O. caerulea* (L.) (W), *O. leaiana* (Kirby) (W), *Hoplitis spinulosa* (Kirby) (RE), *Megachile willughbiella* (Kirby) (U), *M. centuncularis* (L.) (U), *M. ligniseca* (Kirby) (W, new), *M. versicolor* Smith, F. (U, new).

Anthophorinae: *Nomada integra* Brullé (R), *N. rufipes* F. (U), *N. flavopicta* (Kirby) (S, new), *N. fucata* Panzer (RE, new), *N. goodeniana* (Kirby) (U), *N. lathburiana* (Kirby) (W, new), *N. marshalliana* (Kirby) (U), *N. ruficornis* (L.) (U), *N. striata* F. (W), *N. leucophthalma* (Kirby) (U), *N. flava* Panzer (W, new), *N. panzeri* Lepetelier (U), *N. fabriciana* (L.) (U), *N. flavoguttata* (Kirby) (U), *Epeolus cruciger* (Panzer) (W, new), *Anthophora plumipes* (Pallas) (W), *A. furcata* (Panzer) (W).

Apinae: *Bombus lucorum* (L.) (U), *B. terrestris* (L.) (U), *B. lapidarius* (L.) (U), *B. pratorum* (L.) (U), *B. hortorum* (L.) (U), *B. pascuorum* (Scopoli) (U), *B. campestris* (Panzer) (U), *B. rupestris* (F.) (W), *B. sylvestris* (Lepeletier) (U), *B. vestalis* (Geoffroy in Fourcroy) (W), *Apis mellifera* L. (U).

APPENDIX 2

Aculeate Hymenoptera (25 species) added to the records for Shotover Hill in the 1980s by O'Toole and Archer, and not recorded since then.

Myrmica sabuleti Meinert (U), *Lasius fuliginosus* (Latreille) (W), *Cleptes semiauratus* (L.) (S), *Sapyga quinquepunctata* (F.) (W), *Pompilus cinereus* (F.) (U), *Anoplius viaticus* (L.) (S), *Odynerus spinipes* (L.) (U), *Symmorphus gracilis* (Brullé) (W), *Ancistrocerus parietinus* (L.) (U), *A. scoticus* (Curtis) (U), *Vespa crabro* L. (W), *Dolichovespula norvegica* (F.) (U), *Crabro cribrarius* (L.) (U), *Crossocerus palmipes* (L.) (S), *Ectemnius sexcinctus* (F.) (W), *E. lapidarius* (Panzer) (U), *Rhopalum coarctatum* (Scopoli) (U), *Oxybelus argentatus* Curtis (S), *Colletes fodiens* (Geoffroy in Fourcroy) (W), *Andrena thoracica* (F.) (W), *Stelis punctulatissima* (Kirby) (S), *Osmia pilicornis* Smith, F. (R), *O. bicolor* (Schränk) (S), *Bombus rudarius* (Müller) (W), *B. bohemicus* (Seidl) (U).

APPENDIX 3

Aculeate Hymenoptera (62 species) recorded on Shotover Hill before 1939 (Salzman, 1939), and not recorded since then. (Note: Some national statuses may have changed since 1939.)

Anteon gaullei Kieffer (status unknown), *Gonotopus striatus* Kieffer (status unknown), *Cephalonomia formiciformis* Westwood (status unknown), *Bethylus cephalotes* Foerster (U), *B. fuscicornis* (Jurine) (W), *Leptothorax acervorum* (F.) (U), *Lasius mixtus* (Nylander) (U), *Pseudospinolia neglecta* (Shuckard) (S), *Chrysura radians* (Harris) (R), *Chrysis illigeri* Linsenmaier (S), *C. ruddii* Shuckard (U), *C. viridula* L. (S), *Priocnemis agilis* (Shuckard) (S), *Arachnospila spissa* (Schjødte) (U), *A. trivialis* (Dahlbom) (W), *Ceropales maculata* (F.) (R), *Symmorphus connexus* (Curtis) (VR), *Ancistrocerus oviventris* (Wesmael) (U), *Vespula rufa* (L.) (U), *Crossocerus tarsatus* (Shuckard) (U), *C. capitosus* (Shuckard) (U), *C. nigratus* Lepeletier & Brullé (W), *C. vagabundus* (Panzer) (VR), *Ectemnius rubicola* (Dufour & Perris) (RE), *Mimesa bicolor* Jurine (VR), *Diodontus minutus* (F.) (W), *D. luperus* Shuckard (W), *Passaloecus monilicornis* Dahlbom (W), *Spilomena troglodytes* (Vander Linden) (W), *Mellinus crabroneus* (Thunberg) (VR), *Nysson interruptus* (F.) (VR), *Argogorytes fargei* (Shuckard) (R), *Hylaeus signatus* (Panzer) (S), *H. brevicornis* Nylander (W), *Andrena pilipes* F. (S), *A. bimaculata* (Kirby) (S), *A. tibialis* (Kirby) (S), *A. angustior* (Kirby) (W), *A. trimmerana* (Kirby) (S), *A. varians* (Rossius) (S), *A. praecox* (Scopoli) (W), *A. nigriceps* (Kirby) (S), *A. labialis* (Kirby) (W), *A. coitana* (Kirby) (W), *A. alfkenella* Perkins (VR), *A. niveata* Friese (VR), *A. similis* Smith (W), *Lasioglossum laevigatum* (Kirby) (RE), *Sphecodes hyalinatus* von Hagens (W), *S. miniatus* von Hagens (S), *Megachile circumcincta* (Kirby) (U), *Coelioxys elongata* Lepeletier (U), *Nomada obtusifrons* Nylander (W), *N. fulvicornis* F. (S), *N. sheppardana* (Kirby) (RE), *Eucera longicornis* (L.) (R), *Anthophora retusa* (L.) (VR), *Melecta albifrons* (Forster) (W), *Bombus soroensis* (F.) (U), *B. rudarius* (F.) (S), *B. humilis* Illiger (W), *B. barbutellus* (Kirby) (W).